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REGULAR ARTICLE

IS THE MEAT OF WILD WATERFOWL FIT FOR HUMAN CONSUMPTION? PRELIMINARY RESULTS OF CADMIUM AND LEAD CONCENTRATION IN PECTORAL MUSCLES OF MALLARDS AND COOTS SHOT IN 2006 IN SOUTHERN POLAND

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ABSTRACT

Concentrations of cadmium and lead in pectoral muscles of mallards (N = 15) and coots (N = 15) shot on fishponds in Zator area (southern Poland, Europe) were determined with the graphite furnace AAS. Samples were dried and wet digested in the mixture of HNO_3 and $HClO_4$. Median concentration of cadmium was 0.0616 $\mu g.g^{-1}$d.w. among mallards and 0.0868 $\mu g.g^{-1}$d.w. among coots. Concentrations of lead were higher and median run to 0.1898 $\mu g.g^{-1}$d.w. in mallards and to 0.2637 $\mu g.g^{-1}$d.w. in coots. No differences in heavy metals concentrations between species were statistically significant. According to the thresholds for foodstuff given by European Commission, meat of all birds was edible in the aspect of cadmium concentration (only meat of one coot contained cadmium near the given border). In the aspect of lead, 26% of researched birds have concentration beyond the safety limit and their meat was not fit for human consumption. Considering the annually number of shot birds, any kind of monitoring must be planned to assess potential consumers' safety.

Keywords: game meat, metals, waterfowl, lead poisoning, cadmium

INTRODUCTION

Heavy metals are still one of the most importantproblem in the environment (**Nordberg et al., 2007**). Even if the biomonitoringdata show declining levels of heavy metals in the air (**Grodzińska and Szarek-Łukaszewska, 2001**), many other sources of potential poisoning remain. Among all heavy metals, cadmium and lead are known as highly toxic (**Scheuhammer, 1987**). Both of them have high anthropogenic enrichments factors and are commonly used in the industry which is a significant source of them (**Nordberg et al., 2007**). Lead has also another important source in the environment – hunting ammunition and fishing sinkers. Lead pellets which did not hit a target, fall down on the habitat of waterfowl. Birds ingest them by the mistake for little stones (similar mechanism works with lead fishing sinkers). Pellets dissolve in acidic environment of the stomach and get into the bloodstream causing a severe poisoning (**Pain, 1990; Binkowski and Sawicka-Kapusta, 2009**). Poisoned birds are probably under a high pressure of scavengers and predators (**Pain, 1991**). In that case we should consider a probability of xenobiotic biomagnification, which is a problem of the highest importance. In most ecological studies this phenomenon is usually discussed in the environmental aspects. The number of research conducted with the connection to human is significantly lower. In some countries, where amount of consumed game food is big, human organism may accumulate higher concentrations of metals, especially lead (**Johansen et al., 2006**). If eaten carcasses contain high content of metals, they can be transferred into the dish (**Mateo et al., 2007; Millán et al., 2008; Pain et al., 2010**). This phenomenon is influenced by a few parameters, also by the cuisine customs of the country (**Mateo et al., 2007**). In Poland, game waterfowl are eaten mostly by hunters. However, there are a few research considering the quality of meat in the aspects of heavy metals. The aim of this work is to report the concentrations of cadmium and lead in muscles of mallard and coot and to evaluate their fitness for human consumption.

MATERIALS AND METHODS

The research was done with the use of 30 birds collected by hunters in 2006. There were 15 mallards *Anasplatyrhynchos* L. and 15 coots *Fulicaatra* L. Both species are on the list of game in Poland (MŚ 2005a)and are hunted randomly without any selection in August and September (**MŚ, 2005b**).Birds were shot on the area of fish ponds in Zatorduring

commercial hunting (Figure 1). It is a place of a great importance for migratory birds (**Wilk et al., 2010**). Because of plenty wildfowl, each year a few thousands of birds are hunted there according to the game management plan.

Figure 1 Area of carried research – fishponds around Zator (c.a. 40 km from Cracow) in southern Poland

Animals after the shot were identified (according to species) and weighed. Species was determined on the basis of morphological observations. In the way of section, skeletal muscle (*musculuspectoralis major*) of each bird was sampled. All samples after the section were frozen.

After defrosting in the laboratory (in the Institute of Environmental Sciences, Jagiellonian University) each sample (c.a. 1 g w.w.) was weighed, put onto petri dishes and placed in the dryer at 60˚C. After obtaining the stable weight (after c.a. 3 weeks) samples were mineralized in the hot mixture (volume relation 4:1) of nitric (65%) and perchloric(70%) acid using a hot plate mineralizer. Mineralized solutions were diluted up to 10 mL with deionized water (conductivity 18.2 µS). Such prepared samples were ready to analysis with the atomic absorption spectrometer with the graphite furnace (PerkinElmer Aanalyst 800). Each sample was analyzed twice to assure the high quality of the analyses. Coefficient of variation was used to evaluate the precision of the measurements. The accuracy of the whole procedure was checked against the certified reference material (BCR-185R). Results of these analyses amounts: for Cd 103.06% and for Pb 103.04%. Limit of detection was establish on the level of 0.02 $\mu g.l^{-1}$ for Cd and 0.5 $\mu g.l^{-1}$ for Pb.

Statistical analysis was done with Statistica 10 and Microsoft Excel 2010. Final results are presented as concentration in $\mu g.g^{-1}$ of dry weight (d.w.). Normality of the data

distribution and homogeneity of variances were checked with Shapiro W and Levene test. Because not all parametric analysis demands were fulfilled, nonparametric tests were used. As a statistic of the central tendency, the median was used supplemented by the interquartile range (IQR). The significance of the factor "species" was checked with the U Mann-Whitney test ($\alpha = 0.05$).

RESULTS

Median body mass of researched birds was limited into the range between 0.6 up to 1.5 kg. Bigger body mass wasfound among mallards. Median value for this species was 1.14 kg (IQR = 0.28).Analogic value for coots was0.68 kg (IQR = 0.16).The difference between these species was of a statistical significance ($p < 0.0000$).

In three birds (one mallard and two coots) concentration of cadmium was below the detection limit of the AAS spectrometer. Among mallards, the highest value of cadmium concentration runs into 0.1942 $\mu g.g^{-1}$d.w. (Figure 2). The median value was over three times lower – 0.0616 $\mu g.g^{-1}$d.w. (IQR = 0.0913). Median concentration of cadmium in muscles of coots was slightly higher – 0.0868 $\mu g.g^{-1}$d.w. (IQR = 0.0806). Maximum concentration in this species hits 0.1588 $\mu g.g^{-1}$d.w. (Figure 2). The difference between medians of two species was statistically insignificant ($p = 0.5396$).

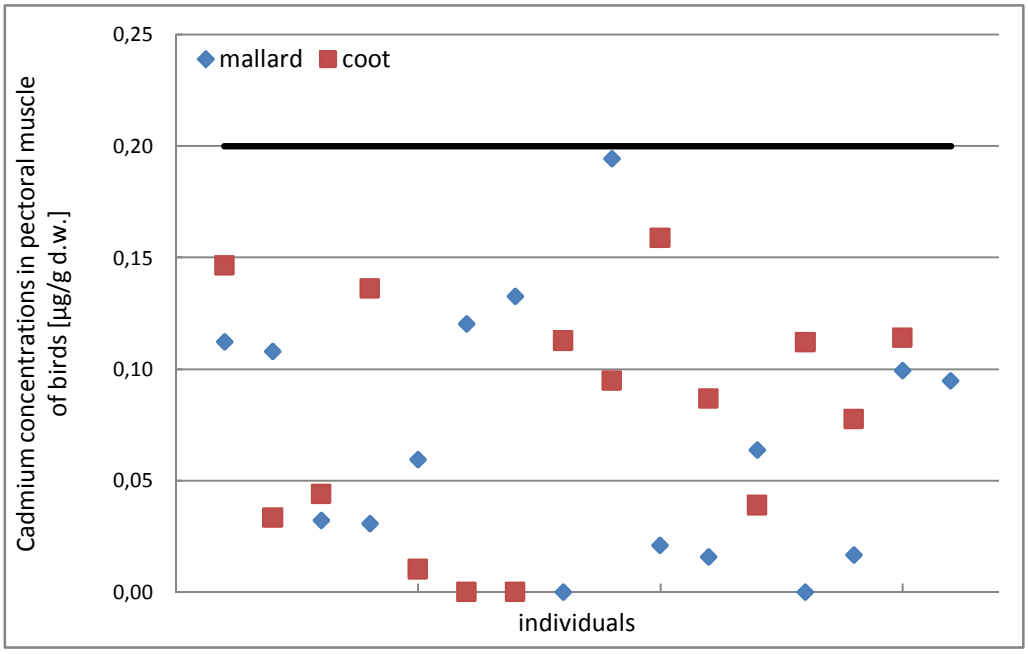

Figure 2 Concentrations of cadmium in pectoral muscle of mallards and coots. Threshold of fitness the meat for human consumption was marked with black line (0.2 $\mu g.g^{-1}$d.w. – originally 0.05 $\mu g.g^{-1}$w.w.)

Similarly as in the case of cadmium, in some birds lead was not found (one mallard and one coot). The highest concentration of this xenobiotic among mallards was 0.9166 µg.g^{-1}d.w. while the median was placed on the level of 0.1898 µg.g^{-1}d.w. (Figure 3). The interquartile range for Pbconcentrations in this species amounts 0.2891 µg.g^{-1}d.w. The maximum concentration of lead in muscles of coot was over 10 times higher than of mallards. It runs into 10.9706 µg.g^{-1}d.w. (Figure 3). The median value of lead concentrations among cootswas 0.2637 µg.g^{-1}d.w. (IQR = 0.8748). Differences between species were not statistically significant (p = 0.4526).

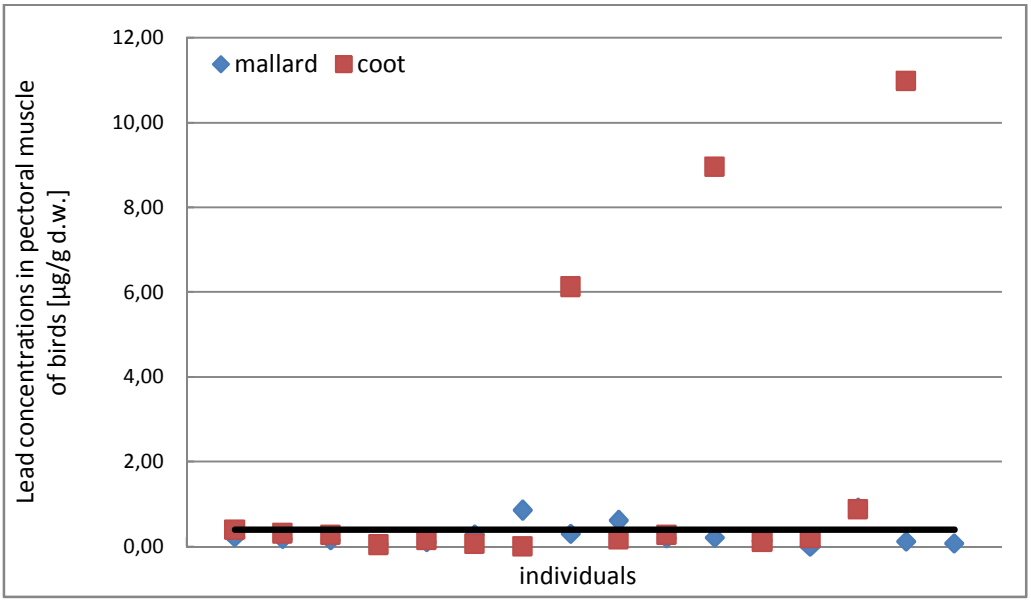

Figure 3 Concentrations of lead in pectoral muscle of mallards and coots. Threshold of fitness the meat for human consumption is marked with black line (0.4 µg.g^{-1}d.w. – originally 0.1 µg.g^{-1}w.w.)

DISCUSSION

Body masses of researched birds were normal according to the literature (**Cramp, 1998**). Body mass is a parameter that can be used to determine lead poisoning. Chronic exposition to this xenobiotic influences the body weight which is seen by significant weight loses (**Pain, 1990**). On that basis, birds hunted on Zator area have no signs of chronic poisoning.

Cadmium concentrations met in birds from southern Poland were comparable with other data from our country. Research of birds from northern Polandshowed mean

concentration equal to 0.11 µg.g^{-1}d.w. (originally 0.027 µg.g^{-1}w.w.[1]). This value is noticeably higher than median of coot's concentration from Zator area. However, not all birds from the North have such a high concentrations, because the variance of those results were significant **(Kalisińska et al. 2004**). According to the data from the neighbor country (**Gasparik et al., 2010**) we can evaluate concentrations from Poland as lower ones. Among mallards from Slovakia, the maximum concentrations of cadmium run into 0.84 µg.g^{-1}d.w. (originally 0.21 µg.g^{-1}w.w.). Hunted coots in Slovakia accumulated even bigger amount of Cd. The mean value was there about 0.28 µg.g^{-1}d.w. (originally 0.07 µg.g^{-1}w.w.) where the maximum value reached 1.4 µg.g^{-1}d.w. (originally 0.35 µg.g^{-1}w.w.).

When we evaluate cadmium concentration in muscles of birds according to the edibility norms we will see that meat of birds hunted from Poland is fit for human consumption. The threshold given by the European Commission (**EC, 2001**) is equal to 0.2 µg.g^{-1}d.w. (originally 0.05 µg.g^{-1}w.w.). However, the cadmium concentrations in muscles of two birds are very close to the safety limit (concentrations over 0.15 µg.g^{-1}d.w.). Looking at birds from Slovakia it is clear that meat of some birds, especially coots can be dangerous to human and should not be eaten.

Lead levels in both species hunted in the south of Poland were higher than cadmium ones (Figure 2 and Figure 3). Around Zator area lead poisoning from ammunition sources is suspected (**Binkowski, 2009; Binkowski and Zakrzewska, 2009; Sawicka-Kapusta and Binkowski, 2009**). Stating of lead poisoning is usually done on the basis of concentration of this element is tissues like blood, liver, kidney and bone (**Pain, 1990**). Muscles are rarely used for this purpose. Lead concentrations in muscles of mallards from Slovakia (mean value in mallards around 1.4 µg.g^{-1}d.w. – originally 0.35 µg.g^{-1}w.w.) were higher than from Zator area (**Gasparik et al., 2010**). Lead concentrations found by researchers in mallards from the north of Poland (**Kalisińska et al., 2004**) are similar to these ones from Zator. Comparing the median value (Zator) with the geometric mean (Szczecin) which is the good measure for the central tendency of highly right-skewed distribution (**Zar, 2010**), we find them almost equal.

Even if muscles are rarely used in lead poisoning diagnosis, this part of the bird body is of the major interest from human nutrition point of view. Muscles constitute over 200 g of edible meat per duck (**Duchesne et al., 2004**). Comparing lead concentrations determined in birds hunted in Zatorto the binding threshold (EC, 2001) which is 0.4 µg.g^{-1}d.w. (originally 0.1 µg.g^{-1}w.w.) seven birds were found unfit for human consumption (Figure 3). Among them there were 3 mallards and 4 coots. Next to them, another coot accumulated almost 0.4 µg.g^{-1}

[1] recalculation done with the assumption that the d.w. constitutes about 25% of thew.w. (Binkowski, unpublished data)

d.w. Summarizing, 26% of hunted waterfowl on the area of fish ponds in Zatorarea are not fit for human consumption. When we evaluate in similar way birds shot in Slovakia, we see that the mean value of lead concentration in that population is higher than the threshold (**EC, 2001; Gasparik et al., 2010**). In that case almost all birds from that area must not be eaten.

CONCLUSION

In Poland over 100 hundred thousand waterfowl are hunted every year. All of these birds are treated as fit for human consumption and all are consumed, mostly by hunters. In the literature cases of lead poisoning among people eating hunted wildfowl are already known (**Bjerregaard et al., 2004; Johansen et al., 2006**). However in Poland any rules or law do not regulate the necessity of checking birds for fitness for consumption. As we saw in the Results section, significant part of waterfowl population accumulated too much heavy metals (especially lead) to be edible. It is impossible to analyze each bird carcass in aspect of heavy metals. However, some kind of monitoring must be planned. The best option seems to be to monitor heavy metal concentrations in randomly selected individuals on the specific area. This procedure should be repeated every year in different part of the country. Next to that, the potential lead sources in birds' habitat should be reduced. Especially lead ammunition should be replaced with the non-toxic one (e.g. steel one).

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